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Plasticity and Imaging Research in Healthy Aging: Core Ideas and Profile of the International Normal Aging and Plasticity Imaging Center (INAPIC)

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Key Words

Aging • Brain • Cognitive training • Motor training • Plasticity • Magnetic resonance imaging

Abstract

The key objective of the International Normal Aging and Plasticity Imaging Center (INAPIC) at the University of Zürich is to facilitate research on normal healthy behavioral and neural development and aging to explore the potential for plasticity and compensation across the lifespan. The INAPIC invites international research groups to submit proposals for collaborative projects on these subjects. It is unique in Europe in giving partner groups 'plug and play' access to state-of-the-art neuroimaging techniques, technical support, and assistance in data collection. This article introduces the core ideas of the INAPIC, its key research areas, and the available infrastructure.

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Normal aging is accompanied by declines in many functional domains, including cognition and motor control, and in the neural systems supporting them. How-

ever, not all functions and neural systems are equally affected, but show great intra- and interindividual variability in age-related trajectories [1–4]. Importantly, in healthy aging, large potentials for compensation and improvement through experience and training (i.e., plasticity) have been demonstrated for both cognitive and motor performance [5–8]. In fact, extensive practice and training with healthy older adults have been found to produce multiple and dissociable physiological and structural changes in specific parts of the brain [5, 9–12]. However, the neural correlates of behavioral plasticity in healthy aging are still poorly understood as are the questions of how long and under which circumstances training effects on both the behavioral and neural level are maintained, transfer to untrained tasks, and how they are modified by age and individual activities and lifestyles across the lifespan. Research at the newly founded International Normal Aging and Plasticity Imaging Center (INAPIC) fills these gaps in knowledge about normal brain aging and the developmental potential of the normally aging individual. Below, the central research areas at the INAPIC, the available infrastructure, and opportunities for research collaboration with the INAPIC are briefly summarized.

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Research Areas at the INAPIC

Research at the INAPIC focuses both on behavioral and neural development and plasticity in healthy individuals across the lifespan and old age, as well as on their interplay and on lifestyle factors influencing them. Specifically, we are interested in the three areas described below.

(1) Normal Healthy Aging: The Longitudinal Healthy Aging Brain Database

Given that even the normally aging healthy human brain undergoes significant structural and functional changes with age [2, 13], one important objective of the INAPIC is to measure longitudinal changes in brain structure, function, and behavior in normal old age. State-of-the-art magnetic resonance imaging (MRI) techniques are applied to derive longitudinal indicators of different neuroanatomical and neurofunctional characteristics and an extensive behavioral testing battery is employed to measure cognitive, motor, and sensory abilities in healthy old adults. These longitudinal neural and behavioral data are accumulated in the longitudinal Healthy Aging Brain (l-HAB) database. As the data collection progresses, we will examine the impact of socioeconomic and autobiographical factors onto cognitive and motor development and plasticity, and, thus, compare healthy normal with illness-affected aging. For this purpose we continuously collect elaborate information on education, job, career, lifestyle, and leisure activities – variables that have been previously suggested to modify aging-related adaptation potentials. Given that plasticity is also inherent in noncognitive and nonmotor domains that are central to successful aging [14, 15], we also collect short-term and long-term longitudinal information on social, affective, motivational, and emotional variables.

(2) Training-Induced Behavioral and Neural Plasticity

Given the scarcity of evidence on neural correlates of training interventions in healthy older individuals [12], one of the INAPIC's main research areas is the investigation of changes in brain anatomy and function induced in healthy elderly by intensive and extensive cognitive and sensorimotor training. The goal is a more elaborate specification of how aging, training characteristics (e.g., training duration, distribution of training sessions, different adaptive procedures or feedback), and characteristics of the trained individuals (e.g., gender, ability,

training experience) affect the extent, pattern, course, and durability of these neural adaptations. To this end, we will conduct longitudinal training studies and apply modern neurophysiological techniques including electroencephalography (EEG), functional and structural MRI, diffusion tensor imaging, and noninvasive brain stimulation.

(3) Behavioral and Neural Compensation across the Lifespan

In the field of neuroscience the term compensation is used with regard to successful performance in tests for specific cognitive or motor functions despite obvious damage or impaired functioning of brain regions through which these functions are normally mediated. One example of such a compensational process is the recruitment of additional brain areas to facilitate performance [13]. Considering, however, that the brain undergoes life-long changes in structure and function, it is exceedingly important to determine developmental changes in the capacity for compensation. Hence, the resulting question is which behavioral and neural processes are contributing to successful performance throughout life and whether and how they change with increasing age. These questions will be addressed using event-related designs – either with EEG or functional MRI – that allow the distinction between neural activity in successful and unsuccessful trials. With this approach conclusions regarding the behavioral and neural mechanisms underlying the stabilization of successful performance across healthy aging can be drawn [16].

Infrastructure at the INAPIC

To advance the understanding of behavioral and neural adaptations associated with healthy aging and induced by training interventions, the following techniques are applied at the INAPIC in addition to behavioral assessments of cognitive and motor functioning: structural and functional MRI, EEG, transcranial magnetic stimulation and transcranial direct current stimulation. The INAPIC owns an MR simulator for familiarization of study participants with the scanner environment as well as training labs with computers, treadmills, and a driving simulator. It conducts longitudinal healthy aging and training studies and an expert review board representing neuropsychological, gerontological, medical, and neuroimaging experts ensures the highest possible quality of the research conducted at the INAPIC.

International Research Collaborations

An important goal of the INAPIC is to establish international research collaborations to promote neuroimaging research on healthy aging and plasticity. Therefore, the INAPIC provides 'plug and play' access to the above-mentioned neurophysiological techniques and technical support and assistance in data collection and analyses. In addition, the I-HAB database constitutes a basis for collaboration enabling, for instance, the combination of similar databases to obtain larger samples and allow even

more powerful analyses. For possible collaborative projects, research proposals can be submitted according to the guidelines outlined on the INAPIC website (<http://www.inapic.uzh.ch>).

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